Association for the Environmental Health of Soils

Session 1: Perchlorate

Thursday, March 23, 2000 Morning Session 8:00am - Noon

Adsorption Characteristics of Perchlorate in Soils
Sridhar Susarla, US EPA, NERL, Athens, GA

Risk Assessment of Perchlorate Contamination at an Agriculture Field
Heriberto Robles, LFR, Inc., Irvine, CA

Perchlorate Uptake in Leafy Vegetation from Fertilizer and Irrigation Water
Stacy Lewis Hutchinson, US EPA, Ecosystems Research Division, Athens, GA

Application of Vascular Plants for Bioremediation of Perchlorate: Unraveling the Mysteries
Sydney T. Bacchus, University of Georgia, Athens, GA

Removal of Perchorate and Trichloroethylene from Water by Terrestrial Plants
Valentine A. Nzengung, University of Georgia, Athens, GA

San Diego, CA
10th annual west coast conference on Contaminated Soils & Water

Risk Assessment of perchlorate CONTAMINATION AT AN AGRICULTURAL FIELD

Heriberto Robles, Ph.D., D.A.B.T.

A farming company in Southern California was informed that one of their irrigation wells had been contaminated with perchlorate. Concerned about the health and legal implications of using water from the contaminated well to irrigate edible vegetables, the company commissioned LFR to assess the potential health risks posed by the presence of perchlorate in water, soil, and vegetables. This presentation provides a brief description of the sequence of events that led to the contamination of an agricultural field, the toxicological properties of perchlorate, the results of the investigation, and recommendations made.

The source of the perchlorate in groundwater was traced back to an aerospace company located six miles upgradient from the site. The concentration of perchlorate in groundwater was found to exceed the California Department of Health Services' Provisional Action Level (in 1997) of 18 micrograms per liter. Soil and groundwater samples collected from the site confirmed the presence of perchlorate in both soil and groundwater.

As part of the investigation, vegetable samples were collected at random from the agricultural field and submitted to an analytical laboratory for perchlorate analysis. Results of the analysis plus the soil and groundwater data that had been previously collected were used to conduct a Risk Assessment. In addition, a bench-scale laboratory study was conducted to estimate perchlorate's degradation rate in soil.

Results of the risk assessment indicated that perchlorate in soil and vegetable material, at the concentrations measured at the site, did not represent a health risk to agricultural workers at the site or to consumers of vegetables grown there. Furthermore, results of the laboratory study indicated that perchlorate degradation in soil takes place at a relatively fast pace. Under the laboratory conditions studied, the half-life of perchlorate in soil was estimated to be 52 hours. According to current literature on the subject, perchlorate can degrade in soil in the presence of organic matter, reducing agents and/or suitable microbial flora. The organic carbon content in the tested soil was 0.7 percent. The presence and concentration of reducing agents and suitable bacteria were not determined. Therefore, the actual mechanism(s) responsible for the perchlorate degradation in soil was (were) not determined.

LFR recommended that the contaminated well be monitored at regular intervals to make sure that its perchlorate concentrations do not increase. At the time of this assessment, it was not clear whether the concentration of perchlorate in groundwater was stable, increasing, or decreasing. Follow-up soil and water analyses have revealed that the perchlorate concentration in groundwater is stable and that, as predicted by the bench scale degradation study, perchlorate is not accumulating in soil.

Adsorption characteristics of perchlorate in soils

Susarla, S., Wood, G., Wolfe, N.L., McCutcheon, S.C., USEPA, Athens, GA.

Perchlorate (ClO4-) is an oxyanion that originates as a contaminant in ground and surface waters from the dissolution of ammonium, potassium, magnesium or sodium salts. Perchlorate is mainly used in solid rocket fuels, explosives, and military batteries. Because of its potential harmful effects perchlorate has recently been added to the EPA's Contaminate Candidate List. The adsorption characteristics of perchlorate in six different sandy soils was examined in laboratory. The results suggest that perchlorate sorption was strongly dependent on pH, temperature and organic matter of the soils. The adsorption was maximum around pH 6.5, while temperature had less significant effect. Organic matter present in the soil was primarily responsible for the sorption of perchlorate. The adsorption data of perchlorate followed a non-linear Freundlich-type isotherm (S = K Cn) with n<1 and K values between 0.76 and 1.25. Chemisorption is the most probable mechanism for perchlorate adsorption in these soils.

Perchlorate Accumulation from Fertilizer in Leafy Vegetation

Stacy Lewis Hutchinson, Sridhar Susarla, Lee Wolfe and Steve McCutcheon

Perchlorate has contaminated water and soils at several locations in the United States. Perchlorate is water soluble, exceedingly mobile in aqueous systems, and can persist for many decades under typical ground and surface water conditions. Perchlorate is of concern because of uncertainties about toxicity and health effects from low levels in drinking water, the impact on ecosystems, and possible indirect exposure pathways for humans from agricultural and other activities. There are very limited data about the possible uptake of perchlorate into agricultural products due to irrigation with contaminated waters or application of fertilizers containing perchlorate. In order, to characterize possible impacts of crop perchlorate interactions, the uptake of perchlorate from fertilizer in leafy garden crops was investigated by applying a nutrient solution containing perchlorate on lettuce (*Lactuca sativa*) and mustard (*Brassica alba*) seedlings based on the recommended application rate for the fertilizer. Four locally purchased fertilizers and an unfertilized control were tested on seedlings grown in 2 different media, washed sand and potting soil. Whole plant samples were taken throughout the growing season. Plant tissues were separated and analyzed for perchlorate and transformation products.

APPLICATION OF VASCULAR PLANTS FOR BIOREMEDIATION OF PERCHLORATE: UNRAVELING THE MYSTERIES

Sydney T. Bacchus, Sridhar Susarla and Steven C. McCutcheon[2]

Recent research suggests that vascular plants may provide a viable means of remediating sites contaminated with perchlorate, a possible endocrine disruptor. If results of in situ and on-site trials are consistent with top results of laboratory experiments, bioremediation of perchlorate using vascular plants could increase efficiency of remediation; reduce initial capital outlay and required maintenance; and transform contaminants into substances that are not hazardous to human health. Results from short-term laboratory-scale experiments with two related species of halophytes, pickleweed (Allenrolfea occidentalis) and perennial glasswort (Salicornia virginica), exemplify the range of variation that may occur under different conditions of ion availability. For perchlorate concentrations typical of contaminated sites (20 ppm), approximately 29% and 43% was depleted from solution within ten days in the presence of pickleweed, for the unwashed-sand treatment with nutrients, and the washed-sand (chloride removed) treatment without nutrients, respectively. For the same concentration of perchlorate and exposure time, approximately 13% and 68% was depleted from solution in the presence of perennial glasswort for washed-sand treatments with and without nutrients, respectively. The efficiency of mass depletion of perchlorate by perennial glasswort in washed-sand, without nutrients treatment, 3138 mg of perchlorate removed per Kg of plant weight was approximately an order of magnitude greater than results for all previously referenced treatments. Analysis of plant tissues confirmed that transformation of perchlorate had occurred in the plants within ten days for these treatments. Depletion of perchlorate from solution in the presence of these species occurs as first-order reactions. Results of this experiment, combined with knowledge of the ecological aspects of these plants, provide the basis for designing more detailed, long-term experiments to resolve the mysteries of phytotransformation processes of perchlorate.

REMOVAL OF PERCHLORATE AND TRICHLOROETHYLENE FROM WATER BY TERRESTRIAL PLANTS

Valentine A. Nzengung, Chuhua Wang and Stacey Box

There are currently no cost-effective technologies that can remove both perchlorate and trichloroethylene (TCE) from drinking water, groundwater or surface water. We investigated the potential effectiveness of selected terrestrial plants for the clean up of a mixed plume of perchlorate and TCE. In separate bench-scale tests, willows and eucalyptus trees were grown in hydroponic bioreactors and dosed with perchlorate, TCE or equal concentrations of both compounds. Depending on the experimental conditions, we observed that perchlorate and TCE were transformed mostly in the root-zone and/or taken up and transformed in the plant tissue. Uptake of perchlorate and TCE into the trees was highest in experiments with nitrate as the nitrogen source in the nutrient solution. Meanwhile rhizotransformation predominated if nitrate was replaced by ammonium/urea as the nitrogen source and the tree had a higher fraction root mass. Phytotransformation of perchlorate and TCE in the plant tissues was verified and confirmed in experiments conducted with the radiolabeled forms of these compounds. No evidence of long-term phytoaccumulation of either contaminant was observed. The results of this study provide evidence that selected plants are effective for clean up of groundwater contaminated with both perchlorate and TCE.